(19) Europäisches Patentamt
European Patent Office
Office européen des brevets

(11) EP 0 897 804 A2

(12) **EUROPEAN PATENT APPLICATION**

(43) Date of publication:
24.02.1999 Bulletin 1999/08

(51) Int Cl.6: **B41J 2/21**

(21) Application number: **98303777.1**

(22) Date of filing: **14.05.1998**

(84) Designated Contracting States:
AT BE CH CY DE DK ES FI FR GB GR IE IT LI LU MC NL PT SE
Designated Extension States:
AL LT LV MK RO SI

(30) Priority: **15.08.1997 US 911242**

(71) Applicant: **Xerox Corporation**
Rochester, New York 14644 (US)

(72) Inventors:
- **Xie, Yonglin**
  Webster, New York 14580 (CH)
- **Tracy, Mark D.**
  Rochester, NY 14617 (US)
- **Ferringer, Michael C.**
  Ontario, NY 14519 (US)
- **Rezanka, Ivan**
  Pittsford, NY 14534 (US)

(74) Representative:
Walker, Antony James Alexander et al
W.P. Thomson & Co.,
Coopers Building,
Church Street
Liverpool L1 3AB (GB)

(54) **Liquid ink printhead**

(57) A liquid ink printer including a liquid ink printhead for ejecting liquid ink drops on a recording medium to form an image thereon having reduced misting defects. A printhead includes a selection circuit (100), coupled to a plurality of transducers (92), for causing non-adjacent nozzles of an array of nozzles (50) to eject liquid ink drops substantially simultaneously. In addition, a method of reducing misting defects during printing of a line of an image by a liquid ink printhead having a plurality of transducers (92) being activatable to eject ink from an array of N nozzles (50) includes the steps of ejecting a first ink drop from a first nozzle and a second ink drop from a second nozzle substantially simultaneously to form a first portion of the line of the image, the first nozzle and the second nozzle being non-adjacent, and ejecting a third ink drop from a third nozzle of the array of nozzles to form a second portion of the line of the image, the third nozzle being located between the first nozzle and the second nozzle. Multiple ripples of the printhead nozzles are made to complete a single line of the image.

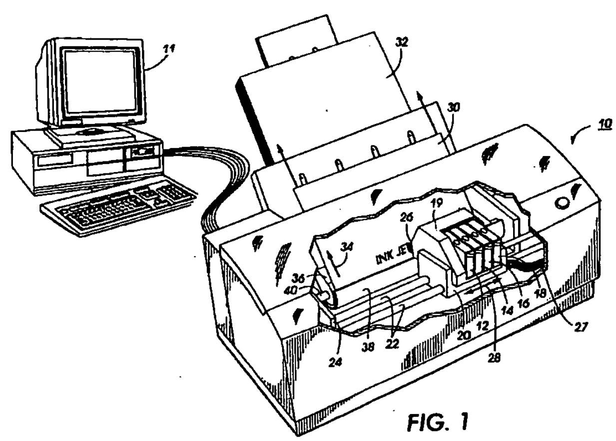

FIG. 1

EP 0 897 804 A2

Printed by Jouve, 75001 PARIS (FR)

Descripti n

[0001] This invention relates generally to liquid ink printers and more particularly to a liquid ink printhead having reduced misting defects.

[0002] The ink jet printhead may be incorporated into either a carriage type printer, a partial width array type printer, or a page-width type printer. The carriage type printer typically has one or more relatively small printheads containing the ink channels and nozzles. The printheads can be sealingly attached to one or more disposable ink supply cartridges and the combined printheads and cartridge assembly is attached to a carriage which is reciprocated to print one swath of information (equal to the length of a column of nozzles), at a time, on a stationary recording medium, such as paper or a transparency. After the swath is printed, the paper can be stepped a distance equal to the height of the printed swath or a portion thereof, so that the next printed swath is contiguous or overlapping therewith. This procedure is repeated until the entire page is printed.

[0003] In contrast, the page width printer includes a stationary printhead having a length sufficient to print across the width or length of a sheet of recording medium at a time. The recording medium is continually moved past the page width printhead in a direction substantially normal to the printhead length and at a constant or varying speed during the printing process. A page width ink-jet printer is described, for instance, in U.S. Patent No. 5,192,959.

[0004] Printers typically print information received from an image output device such as a personal computer. Typically, these output devices generate pages of information in which each page is in the form of a page description language (PDL). An electronic subsystem (ESS) in the printer transforms the page description language into a raster scan image which is then transmitted to a peripheral or image output terminal (IOT). The raster scan image includes a series of scan lines in which each scan line contains information sufficient to print a single line of information across a page in a linear fashion. In the page description language, printed pages also include information arranged in scan lines.

[0005] In known thermal ink jet printheads or printbars which print a single line of pixels in a burst of several banks of nozzles, each bank prints a segment of a line. The banks of nozzles are typically fired sequentially and the nozzles within a bank are fired simultaneously. An ink jet printbar having banks of nozzles is described in U.S. Patent No. 5,300,968 to Hawkins. These printbars include a plurality of printhead dies, wherein each die prints a portion of a line. Within the die, the banks of nozzles print a segment of the portion of the line.

[0006] Various printers and methods are illustrated and described in the following disclosures which may be relevant to certain aspects of the present invention.

[0007] In US-A-5,057,855 to Damouth, a thermal ink jet printed and a control arrangement therefore is described. The printed includes a housing defining a plurality of ink receiving and emitting chambers with each chamber extending from an aperture from the ink emitting edge of the housing into the interior thereof. A plurality of heating elements are included, one heating element positioned in each of the chambers. The plurality of heating elements are included, one heating element positioned in each of the chambers. The plurality of heating elements include first and second terminals with at least one of the heating elements in communication with at least one of the chambers. A control means is operable to connect the second terminal of a selected one of the heating elements with a power source.

[0008] US-A-5,300,968 to Hawkins describes an apparatus for stabilizing thermal ink jet printer spot size. A thermal ink jet printhead includes a thermal ink jet chip comprising thermal ink jet heating elements and power MOSFET drivers to turn the heating elements on and off. Up to four jets are fired together.

[0009] In accordance with one aspect of the present invention, there is provided a liquid ink printhead for ejecting liquid ink drops on a recording medium to form an image thereon. The printhead includes a plurality of transducers, each of the plurality of transducers being activatable to generate a liquid ink drop, an array of nozzles, operatively associated with the plurality of transducers, each of the plurality of nozzles for ejecting liquid ink drops in response to one of the plurality of transducers being activated, and a selection circuit, coupled to the plurality of transducers, for causing non-adjacent nozzles from the array of nozzles to eject the liquid ink drops substantially simultaneously.

[0010] Pursuant to another aspect of the present invention, there is provided a method of reducing misting defects generated during printing of a line of an image by a liquid ink printhead having a plurality of transducers being activatable to eject ink from an array of nozzles. The method includes the steps of ejecting a first ink drop from a first nozzle and a second ink drop from a second nozzle of the array of nozzles substantially simultaneously to form a first portion of the line of the image, the first nozzle and the second nozzle being non-adjacent, and ejecting a third ink drop from a third nozzle of the array of nozzles to form a second portion of the line of the image, the third nozzle being located between the first nozzle and the second nozzle.

[0011] In accordance with still another aspect of the invention, there is provided a method of reducing misting defects during printing of a line of an image by a liquid ink printhead having a plurality of transducers being activatable to eject ink from an array ofN nozzles. The method includes ejecting an ink drop from a first nozzle and from every mth nozzle therefrom of the array of N nozzles substantially simultaneously to form a first portion of the line of the image with m being equal to or greater than two and ejecting an ink drop from a second nozzle and from every mth nozzle therefrom

substantially simultaneously to form a second portion of the line of the image.

[0012] Embodiments of the present invention will now be described, by way of example, with reference to the accompanying drawings in which:

[0013] FIG. 1 illustrates a perspective view of a color inkjet printer incorporating the present invention.

[0014] FIG. 2. illustrates a perspective view of an ink jet printhead.

[0015] FIG. 3. illustrates a schematic circuit diagram of an ink jet integrated circuit of the prior art.

[0016] FIG. 4 illustrates a schematic circuit diagram of one embodiment of an ink jet integrated circuit of the present invention.

[0017] FIG. 5 illustrates a schematic circuit diagram of another embodiment of an ink jet integrated circuit of the present invention.

[0018] FIG. 1 illustrates a perspective view of a color thermal ink jet printer 10 which incorporates a preferred embodiment of the present invention. Printer 10 is exemplary only. The invention can be practiced in other types of thermal ink jet printers, as well as other reproduction devices including liquid ink printers driven by signals from a document raster input scanner or signals received from a computing device, such as a personal computer 11. Printer 10 includes four ink jet ink containers 12, 14, 16, and 18 mounted in a print cartridge 19 on a carriage 20 supported by carriage rails 22. The carriage rails 22 are supported by a frame 24 of the ink jet printer 10. The printhead cartridge, which comprises the ink containers, contain ink for supply to one or more thermal ink jet printheads 26 which selectively expels droplets of ink under control of electrical signals received from a controller (not shown) of the printer 10 through an electrical cable 27. The printhead 26 contains a plurality of ink channels which carry ink from one or more of the ink containers 12, 14, 16, and 18 to respective ink ejecting orifices or nozzles of the printhead 26.

[0019] When printing, the carriage 20 reciprocates or scans back and forth along the carriage rails 22 in the direction of an arrow 28. As the printhead 26 reciprocates back and forth across a recording medium 30, fed from an input stack 32 containing, for instance, sheets of paper or transparencies, droplets of ink are expelled from selected ones of the printhead nozzles towards the recording medium 30. The ink ejecting orifices or nozzles are typically arranged in a linear array substantially perpendicular to the scanning direction 28 and consequently images are created line by line in multiple swaths of the printhead. In pagewidth printers a single line of information crosses substantially the entire width or length of the recording medium. If printing in color, such a linear array can be segmented such that segments of the array deposit different colors of ink to complete a color image. It is also possible that each of the ink tanks be connected to or include an individual linear nozzle array such that the printer includes four linear arrays, one for each ink. Combinations of segmented arrays and individual arrays are also possible. During each pass of the carriage 20, the recording medium 30 is held in a stationary position. At the end of each pass, the recording medium is stepped in the direction of an arrow 34. For a more detailed explanation of the printhead and printing thereby refer to U.S. Patent No. 4,571,599 and U.S. Patent No. Re. 32,572.

[0020] The single recording sheet 30 is fed from the input stack through the printer along a path defined by a curved platen 36 and a guide member 38. The sheet 30 is driven along the path by a transport roller 40 as is understood by those skilled in the art or, for instance, as illustrated in U.S. Patent No. 5,534,902. As the recording medium 30 exits the slot between the platen 36 and guide member 38, the sheet 30 is caused to reverse bow such that the sheet is supported by the platen 36 at a flat portion thereof for printing by the printheads 26.

[0021] As illustrated in FIG. 2, an exemplary ink jet printhead 26 includes a single thermal ink jet printhead die 42 having an individual heater die 44 and an individual channel die 46. The channel die includes an array of fluidic channels 48, each being terminated by a nozzle 50, in a substantially linear array of nozzles, which bring ink into contact with resistive heaters which are correspondingly arranged on the heater die.

[0022] In a printer having a printhead with equally spaced nozzles, each of the same size producing ink spots of the same size, the pixels are placed on a square first grid having a spacing between the marking transducers or channels on the printhead. The nozzles 50 which are spaced from one another a specified distance d, also known as the pitch, deposit ink spots or drops on pixel centers along a line substantially parallel to the linear array. Typically, the nozzles and printing conditions are designed to produce spot diameters of approximately 1.414 (the square root of 2) times the grid spacing. This allows complete filling of space, by letting diagonally adjacent pixels touch.

[0023] Figure 3 is a schematic diagram illustrating the basic elements of a prior art printhead integrated circuit to selectively expel ink from the array of linearly aligned nozzles. In one particular embodiment, a thermal ink jet integrated circuit 60 includes a plurality of thermal ink jet heating elements 62 which are powered by a forty volt supply line 64 produced by a power supply 66. Each of the heating elements is additionally coupled to a power MOS FET driver 68 having one side thereof coupled to a ground 70. The power MOS FET drivers energize the heating elements for expelling ink from the nozzles. Although the thermal ink jet circuit can include any number of ink jet heating elements 62 at densities of for instance, 300, 600, or greater heaters per inch, the present invention is applicable to any number of ink jet heating elements 62. Eight heating elements 62 are shown in FIG. 3 for illustrative purposes.

[0024] Control of each of the power MOS FET driver 68 is accomplished by an AND gate 72 having the output thereof coupled to the gate of the driver 68. The power supply 66 provides an output of greater than 5 volts and typically of 13

volts for supply to the AND gates.

[0025] To reduce the amount of circuitry necessary to individually fire each of the heaters 62, the thermal ink jet integrated circuit 60 controls up to four heaters 62 at a time by using a drop ejector controller 74, for instance, a bi-directional N bit pointer shift register. The controller 74 controls four of the AND gates 72 at a time which are coupled to adjacently located heaters which in turn are associated with four adjacently located nozzles. Printing is initiated with a single one bit pointer which begins at the left most side of the controller 74 at a line or conductor 76. The pointer bit starts on the left-hand side and propagates to the right-hand side or in the alternativ starts on the right-hand side and propagates to the left-hand side depending on the state of a data line 78 at the time a reset line 80 goes high. Bi-directional propagation of the one bit is used for bi-directional printing. The length of the shift register 74 depends on the number of adjacent heaters addressed simultaneously and the total number of heaters in the printhead itself. For instance, a printhead, including 192 heaters addressed four at a time, would include a forty-eight bit pointer shift register as would be understood by one skilled in the art.

[0026] When the controller 74 is reset by the reset line 80, four bits of data are loaded from the data line 78 into a four bit shift register 82. The four bit shift register 82 is shifted by a shift line 84 which receives shift information from a printhead controller as is understood by one skilled in the art. The four bits of data, which have been loaded into the four bit register 82, control whether or not any one of heating elements 62 within a group of four adjacently located heating elements will be energized. A fire control pulse received from the printhead controller at a fire line 86 controls the amount of time that individual heaters 62 are energized. During the cycle of the fire control pulse received over the fire line 86, four new bits of information are loaded into the four bit shift register 82. The completion of the fire cycle advances the shift register 74 pointer bit one position to address the next group of four adjacently located heaters and the fire cycle begins again. Once all of the heaters have been addressed, the shift register 74 is reset by the reset line 80. A latch 88 is used to latch the information from the four bit shift register 82 onto each of the individual AND gates for energization.

[0027] The heating elements 62, within each four nozzle segment, are selected and fired simultaneously to eject ink droplets from the associated nozzles if all four of the heating elements are selected according to the latched data. After a first group of four heating elements have been fired simultaneously, then a second group of four adjacently located heating elements is selected and energized accordingly in response to the data. Consequently, groups of four heating elements 62 are fired sequentially one after another until all of the heating elements of a printhead have been fired. Due to the relative motion of the paper 30 and the printhead 26 during scanning and the finite amount of time necessary to energize the heaters 62 to allow for the electronics to prepare for the next firing, a single printed line resulting from every nozzle of the printhead is not actually collinear but rather is formed of small line segments four nozzles long which are slightly staggered with respect to one another. The stagger distance is the distance traveled during the firing period.

[0028] The stagger distance is relatively small from one bank of four nozzles to the next bank of four nozzles. For instance, at a carriage speed of 15 inches per second and a firing period of 3.2 microseconds, a delay of 48 microinches (1.2 micrometers) results. Multiplying this number by the number of banks of four of the heating elements 62 within a printbar results in a delay or stagger from the top most nozzle of the printbar to the bottom most nozzle of the printbar.

[0029] While the printhead of FIG. 3 generates printed images of good quality in low area coverage images such as 1/2-tone and 1/4-tone, it has been found that solid area coverage images printed with such a printhead suffer from a phenomenon known as misting. Misting occurs when multiple small droplets of ink are generated by splashing and interaction between neighboring drops landing on the receiver sheet substantially simultaneously to create small air-borne droplets. Such misting effects are undesirable since the ink contained within the small droplets generated is deposited on the recording medium in areas which are typically undesirable. Misting shows as background near solid areas and can be strongly influenced by air flow and in some case, by electrical fields. The mist drifts within the air gap between the printhead and the paper and will not only produce an objectionable artifact or document defect, but will also contaminate adjacent structures including the printhead itself. It has been found that misting is caused mainly by the splatter of ink drops while the ink drops are spreading on the recording sheet and colliding with similarly moving ink drops typically located along a line and being deposited at adjacent pixel positions. This effect is prominent when adjacent drops arrive simultaneously at the receiver sheet. In addition the effect has been shown to occur between the collision of the spreading ink from neighboring drops which causes misting defects on solid coverage prints.

[0030] Colored images which show the most misting defects include those made by printheads that fire ink from eight adjacent channels at a time. In addition it has been found that the propensity of splatter and misting sharply increases with increasing resolution. Consequently, the reduction of misting defects becomes much more important since market pressure toward increasing the resolution of thermal ink jet printheads has increased. In addition to nozzle timing, ink splatter is also dependent on other variables such as ink viscosity, surface tension, drop volume, and drop velocity. These variables are, however, difficult to control or are determined by other factors. Consequently, it is proposed that controlling the timing between the ejection of drops from adjacent channels and increasing the physical separation distance between channels fired substantially simultaneously is preferred to reduce or substantially elimi-

nate any misting problems.

[0031] It is proposed to arrange the firing scheme of the printhead such that there is always a time delay between the arrival of adjacent drops at the recording medium. While various known software algorithms, such as checkerboard printing, can be used to introduce a time delay between the arrival of adjacent drops at the recording medium, such methods can be inefficient since complex manipulation of the image data is necessary. In addition such printing algorithms typically require that the printhead traverse the recording medium in multiple passes thereby slowing down the printing speed and effectively increasing the amount of time necessary to complete the printing of an image. Consequently, it has been found that misting or splatter can be prevented or substantially reduced most efficiently by changing the way a printhead, such as that illustrated in FIG. 3 ejects ink drops.

[0032] FIG. 4 illustrates one embodiment of a printhead 90 incorporating the present invention. The distance between adjacent nozzles that eject ink simultaneously is increased and/or a delay time between firing adjacent nozzles is increased to avoid simultaneous generation of ink drops which would otherwise land adjacently on the recording medium having misting defects.

[0033] The printhead 90 includes a plurality of heaters 92, each of which is driven by a drive transistor 94, such as a MOSFET transistor. While the heaters 92 are arranged side by side on a silicon substrate at a specified resolution as previously described, adjacent heaters are not simultaneously energized. Instead, non-adjacent heaters are simultaneously energized and may be separated by one or more heaters along the row of heaters comprising the entire printhead. In the configuration of FIG. 4, a first heater 92A and a second heater 92C (which are separated by a third heater 92B) are controlled by an AND gate 96A and AND gate 96C such that when an activation signal is generated on a control line 98 both the AND gates 96A and 96C are enabled for firing the associated heaters 92A and 92C. A drop ejector controller 100 selects line 98, as previously described, to select heaters 92A and 92C. Each heater is then energized depending on an image signal received over a line 102 and a line 104. Image signals transmitted over the lines 102 and 104 are received over a data line 106, as previously described, which are shifted by a four bit shift register 108 responsive to a signal transmitted by a shift line 110 and latched by a plurality of latches 112. More than two heaters may be controlled by a single control line coupled to the controller.

[0034] Once the heaters 92A and 92C have generated sufficient thermal energy to cause the ejection of ink from associated channels, a next group of non-adjacent heaters as well as associated AND gates are selected for ejecting ink. In one mode of operation, a heater 92B and a heater 92D, respectively controlled by an AND gate 96B and AND gate 96D, eject ink from associated nozzles according to signal information transmitted by a line 114 and a line 116. The AND gates 96B and 96D are selected by a selection line 118 coupled to the drop ejector controller 100. This mode of operation is also known as a "bang-bang" mode where the odd heaters in a group of heaters are fired before the firing of the even heaters within the same group. It has been found, however, that a small time delay must be introduced between the arrival times of the drops generated by the heaters 92A and 92C and the drops generated by the heaters 92B and 92D. The minimum delay time has been found to be between approximately two microseconds and preferably approximately four microseconds to avoid interaction between adjacently generated ink drops. Once the heaters 92C and 92D are energized, a next segment of four image bits are loaded into the latches 112. The heaters 92E and 92G are simultaneously selected by a selection line 120 through associated AND gates 96E and 96G. After the ejection of ink, the heaters 92F and 92I are selected and eject ink simultaneously in response to image information transmitted over the lines 114 and 116 as previously described.

[0035] In addition to the so-called "bang-bang" mode of operation, the printhead 90 can be operated such that the drop ejector controller would ripple through all the odd numbered heaters of the printhead in a first instance and then ripple through all the even numbered heaters in a second instance of firing of the printhead to complete printing of one line of a swath of information for a scanning printhead or for printing a single scan line in a page width printhead. For instance, in a first ripple of the exemplary printhead 90, the heaters 92A, 92C, 92D, 92G, 92I, and 92K, would be fired in the first ripple. In a second ripple of the printhead, the evenly spaced heaters 92B, 92D, 92F, 92H, 92J, and 92L, would be selected by the drop ejector controller 100. In such a printing system, however, alternating bits of the received data are printed such that the latch 112 must receive a single line of image information two times to complete the printing of an image. Other data transmission schemes are also possible, including using different latch arrays for odd and even data. Since only a portion of the heaters are fired during each ripple, the distance between adjacent channels that are fired simultaneously can be selected to be larger than the spot size so that adjacent ink drops do not interact with each other.

[0036] This method of firing also reduces any cross-talk that might occur between adjacent channels. Cross-talk is the interaction a firing channel exerts on adjacent firing or non-firing channels through leaking channel walls or through the ink reservoir behind the channels. One outcome of cross-talk is to cause the adjacent channels to shoot a bigger and faster drop if the adjacent channels are fired substantially simultaneously. Another outcome of cross-talk is to cause severe bulge or unintended drop ejection from the adjacent non-firing channels, which are identified to cause aggravated frontface flooding and printing defects.

[0037] This method of firing also increases group firing frequency response when multiple channels are fired sub-

stantially simultaneously. In another word, this method of firing decreases group firing channel refill time when multiple channels are fired substantially simultaneously.

[0038] While known scanning printheads typically include a single printhead die including a plurality of heaters and associated channels, partial width and page width printheads include a number of dies. Dividing a single printhead die which has a plurality of N heaters and associated channels into k groups, each of the k groups would include n x m heaters, where n channels are fired simultaneously with every mth channel of the n channels being fired simultaneously. In a first ripple, n channels (every mth channel) are fired in each group starting with the first channel in the group and rippling through each of the k groups within a single printhead die to form a portion of a line of the image. A following ripple begins by firing the ith ($2 \le i \le m$) channel and every mth channel therefrom ejecting ink to form another portion of the line of the image. It therefore takes m ripples to complete printing a scan line. The number of enables necessary in each ripple is equal to the number of groups k which satisfies the following relation:

$$N = nmk$$

[0039] There are n x k channels fired in each ripple. If the time between enables is T, then the time it takes to complete each ripple is $t = k \times T$ which is also equivalent to the minimum delay time between firing adjacent channels. For instance, in a printhead having N = 384 nozzles where n is equal to eight and T is equal to four microseconds, the parameters of possible multiple ripple firing modes are listed in Table 1.

Table 1

m (Ripples/ Line	nm (Channels/Group)	k (Enables/Ripple)	D (μm)	t (μsec)	dx (μm)
2	16	24	84	96	9.6
3	24	16	126	64	12.8
4	32	12	168	48	14.4
6	48	8	252	32	16.0
8	64	6	336	24	16.8
12	96	4	504	16	17.6
16	128	3	672	12	18.0
24	192	2	1008	8	18.4

[0040] As can be seen from the table, with increasing values of m, the value of D, the distance between adjacently fired nozzles of the printhead, increases monotonically. In addition the value oft decreases monotonically and the value of dx, the offset distance between spots of the first and the last ripples in the carriage travel direction due to delay in firing time between the first and the last ripples, increases monotonically. To prevent misting, large D's (m) and large t's are desirable. On the other hand, dx should be as small as possible to avoid visible raggedness during printing which requires a small m. Therefore a compromise has to be achieved among D, t, and dx to obtain a good result. It is therefore desirable that the minimum value of D should be larger than the maximum desired spot size, the minimum value of t should be larger than the maximum spreading time of ink drop on the paper, and the maximum value of dx should be that no raggedness is visible.

[0041] As an example, in a 600 spot per inch printhead generating a drop volume including a spot size no larger than approximately 120 micrometers, m is greater than or equal to 3, and D is greater than or equal to 126 micrometers. Since it has been found that the amount of time necessary for an ink drop to spread on the paper is on the order of several microseconds, depending on ink viscosity, surface tension, drop volume, drop velocity, and other factors, all of the configurations listed in Table 1 except for the last where m is equal to 24 provides adequate delay time between firing adjacent channels. It can be seen from Table 1 that moving down the m column where the number of ripples per line increases, the corresponding dx increases as well while the spacial frequency decreases resulting in the edge raggedness becoming more visible. According to the desired characteristics, therefore, the configurations of m = 3 and m = 4 can be considered to be the preferred choices for the 600 spot per inch printhead. It is apparent that similar analysis can be applied to other printers and printheads to determine the optimum firing mode based on the criteria for D, t and dx described herein.

[0042] A printhead 130 of FIG. 5 illustrates the embodiment where m is equal to four. As can be seen, every fourth heater is selectively activated simultaneously such that a first group of two heaters 132A and 132B are simultaneously activated through a control line 134 coupled to a controller 136 through an AND gate 138A and 138B, respectively. After the heaters 132A and 132B simultaneously eject ink, if directed by the data received over the corresponding signal transmission lines, a second group of heaters including a heater 140A and 140B are selectively controlled over a selection line 142 of the drop ejector controller 136 through associated AND gates 144A and 144B. The controller

136 would continue to select every fourth heater and associated AND gates of the remaining heaters in the first ripple of the entire printhead including the remaining heaters, which are not illustrated.

[0043] In a second ripple of the printhead, a heater 146A and a heater 146B are controlled simultaneously through a control line 148 and through associated AND gates 150A and 150B. In this second ripple of the printhead, every fourth heater starting from the third heater 146A is addressed. In a third ripple of the printhead, a heater 152A and 152B are addressed by a control line 154 through associated AND gates 156A and 156B. Again, in this third ripple of the printhead, every fourth heater starting from the second heater 152A is addressed. In the fourth and final ripple of the printhead, a heater 158A and 158B are addressed by a control line 160 and every fourth heater spaced from the heater 158A is addressed to complete the printing of a single line of the entire printhead. It has been found that this pattern or sequence starting the first ripple from the first heater, the second ripple from the third heater, the third ripple from the second heater, and the fourth ripple from the fourth heater is preferable not only in reducing or eliminating spatter but also in the reduction or elimination of crosstalk.

[0044] In recapitulation, there has been described a liquid ink printer having reduced misting defects. It is, therefore, apparent that there has been provided in accordance with the present invention, a liquid ink printer having a liquid ink printhead which ejects ink from non-adjacent nozzles simultaneously. The printhead includes a plurality of transducers and a linear array of nozzles, operatively associated therewith, and a selection circuit, coupled to the plurality of transducers, selecting non-adjacent nozzles from the linear array of nozzles to eject the liquid ink drops substantially simultaneously.

[0045] While this invention has been described in conjunction with a specific embodiment thereof, in an ink jet environment, it is evident that many alternatives, modifications, and variations will be apparent to those skilled in the art. For instance, the present invention is not limited to the embodiments shown, but is applicable to any such printer and printhead where a plurality of non-adjacent transducers are coupled together through a common control line such that a plurality of the coupled non-adjacent transducers are energized substantially simultaneously. For instance in one practical embodiment of the present invention, the printhead could include a resolution of 600 drops per inch and have sixteen non-adjacent transducers being energized substantially simultaneously. In addition, the present invention while being described with regards to a thermal ink jet printhead is not limited thereto and other known ink jet printheads having other types of transducers, such as piezoelectric, are also possible. Accordingly, it is intended to embrace all such alternatives, modifications and variations that fall within the spirit and broad scope of the appended claims.

Claims

1. A liquid ink printhead (12) for ejecting liquid ink drops on a recording medium (30) to form an image thereon, comprising:

    a plurality of transducers (92), each of said plurality of transducers being activatable to generate a liquid ink drop;
    an array of nozzles (50), operatively associated with said plurality of transducers (92), each of said plurality of nozzles (50) for ejecting liquid ink drops in response to one of said plurality of transducers being activated; and
    a selection circuit (100), coupled to said plurality of transducers (92), for causing non-adjacent nozzles (50) from said array of nozzles to eject the liquid ink drops substantially simultaneously.

2. The liquid ink printhead of claim 1, wherein said selection circuit (100) includes a selection line coupled to a first one (92A) and a second one (92C) of said plurality of transducers, said first one and said second one of said plurality of transducers being separated by at least one (92B) of said plurality of transducers, and said selection line (100) transmitting a selection signal selecting said first one and said second one of said plurality of transducers simultaneously.

3. The liquid ink printhead of claim 2, wherein said selection circuit includes a second selection line coupled to a third one (92B) of said plurality of transducers, said third one (92B) of said plurality of selection lines being located between said first one (92A) and said second one (92C) of said plurality of selection lines.

4. The liquid ink printhead of claims 1, 2 or 3, wherein said plurality of transducers (92) comprise a plurality of thermal transducers.

5. The liquid ink printhead of any preceding claim, wherein said selection circuit (100) includes a plurality of selection lines, each of said selection lines being coupled to at least two of said plurality of thermal transducers.

6. A method of reducing misting defects during printing of a line of an image by a liquid ink printhead having a plurality of transducers being activatable to eject ink from an array of nozzles, comprising;

   ejecting an ink drop from a first nozzle and from an mth nozzle therefrom of the array of nozzles substantially simultaneously to form a first portion of the line of the image with m being equal to or greater than two; and ejecting an ink drop from a second nozzle and from an mth nozzle therefrom substantially simultaneously to form a second portion of the line of the image.

7. The method of claim 6, wherein said second ejecting step comprises ejecting an ink drop from the second nozzle with the second nozzle being adjacent to the first nozzle.

8. The method of claims 6 or 7, wherein the second nozzle is located between the first nozzle and the mth nozzle therefrom.

9. The method of claim 8, comprising ejecting an ink drop from an mth nozzle and from every mth nozzle therefrom substantially simultaneously to form a last portion of the line of the image.

10. The method of claim 9, wherein m is equal to two.

11. The method of claim 9, wherein m is equal to four.

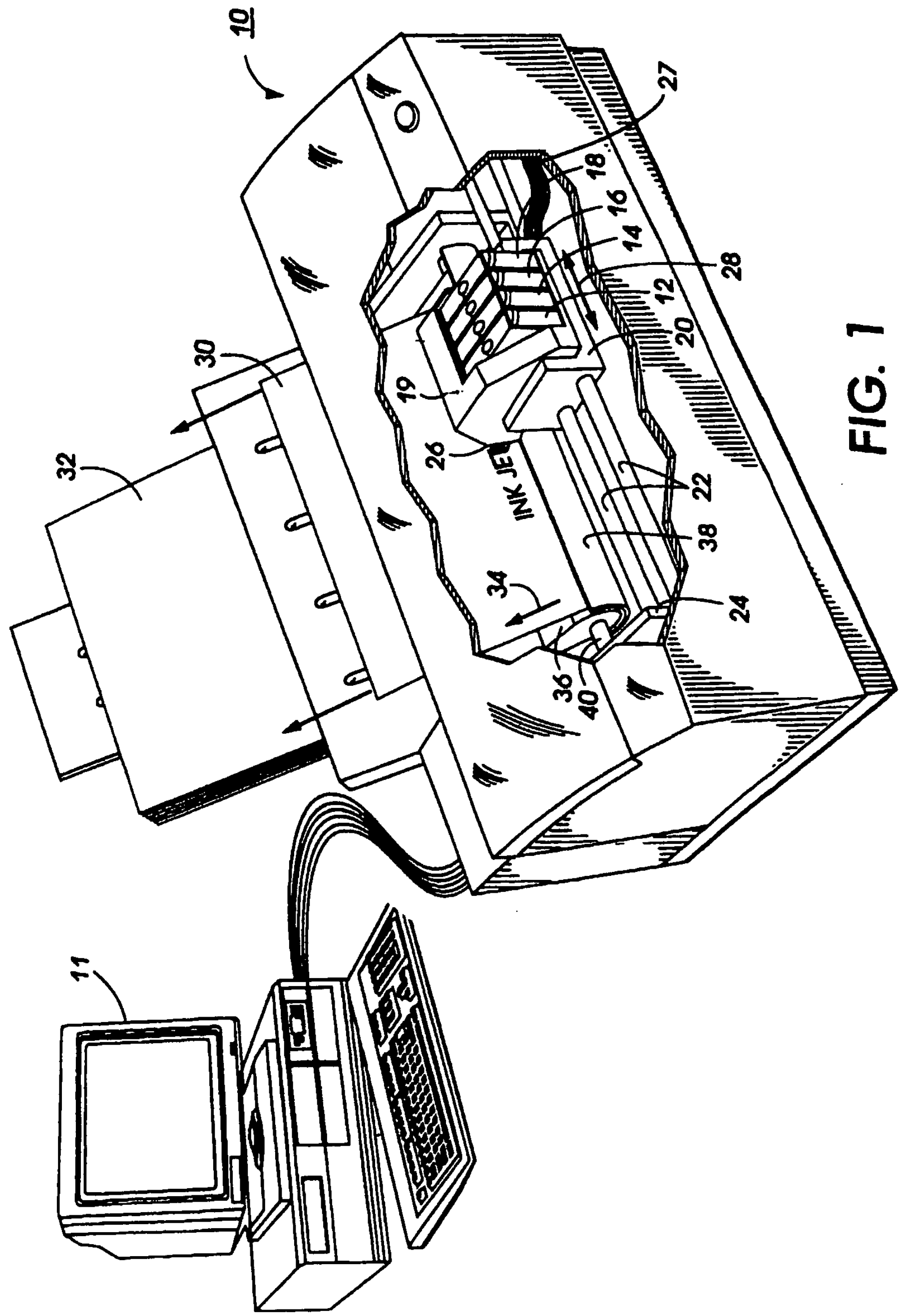

FIG. 1

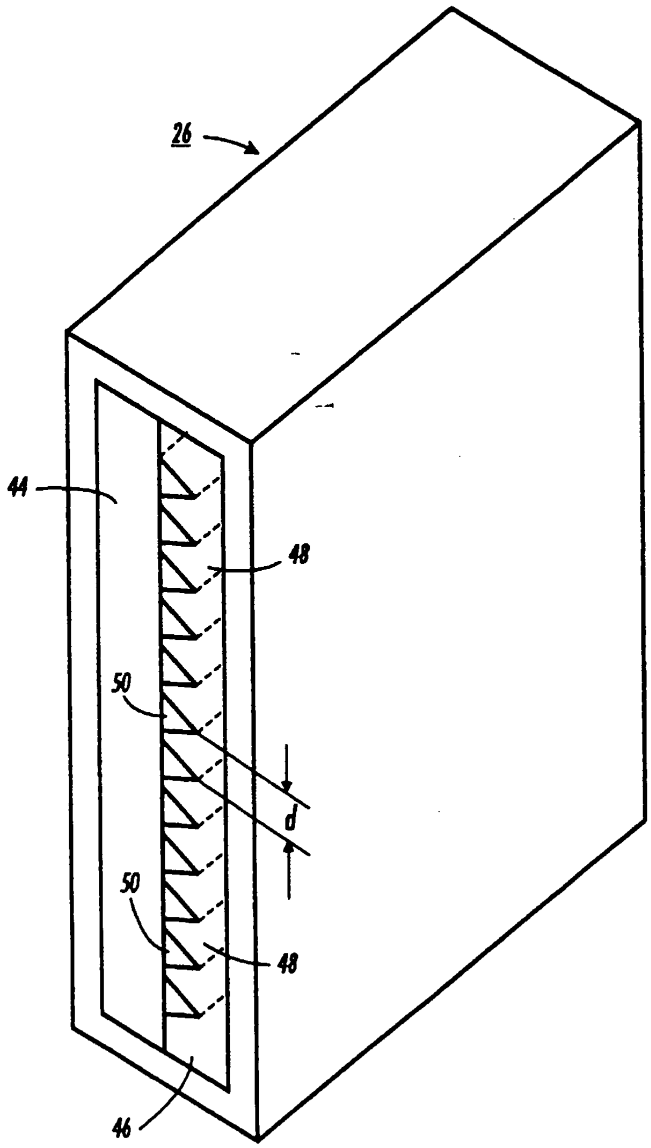

FIG. 2

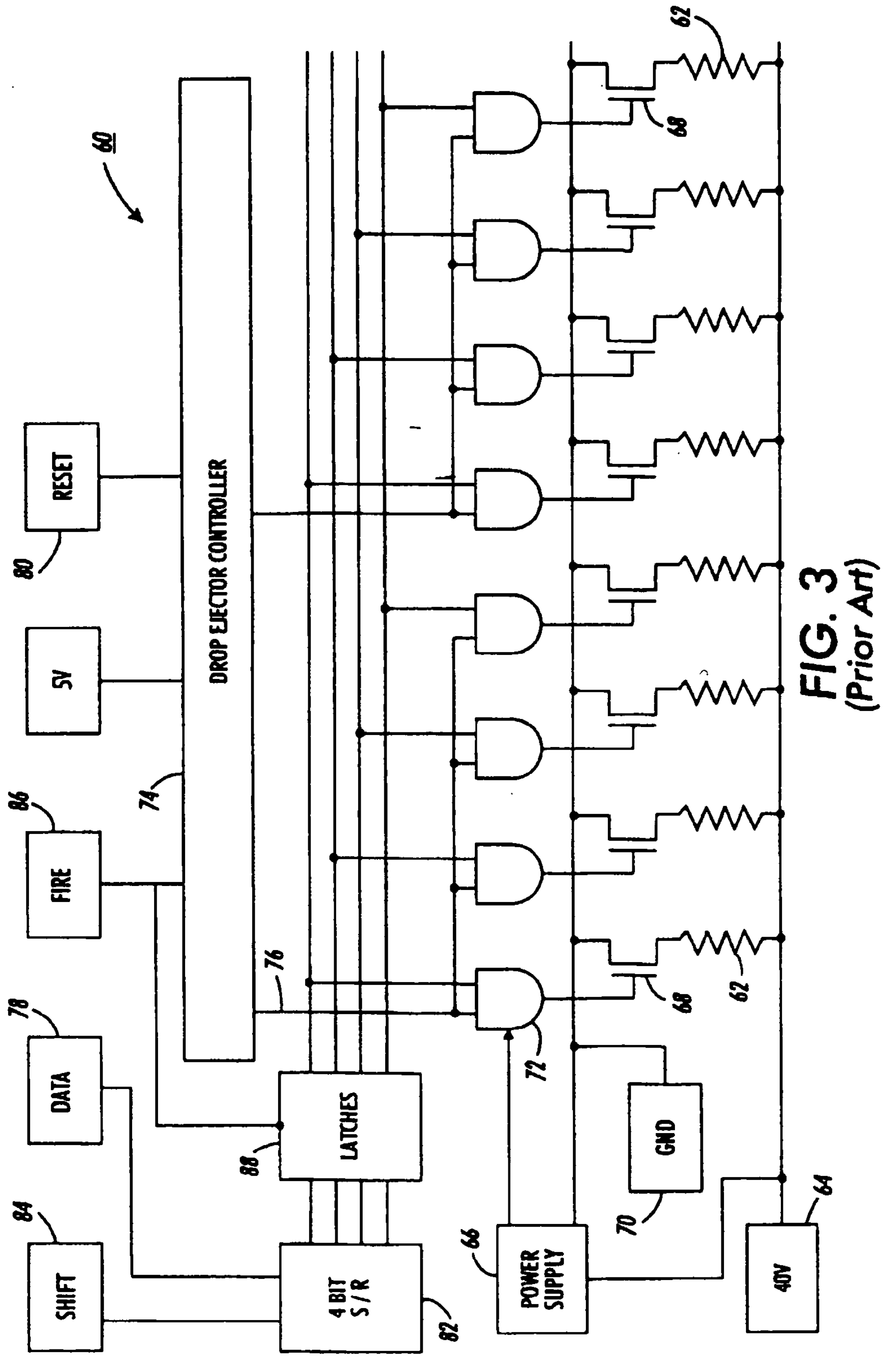

FIG. 3
(Prior Art)

EP 0 897 804 A2

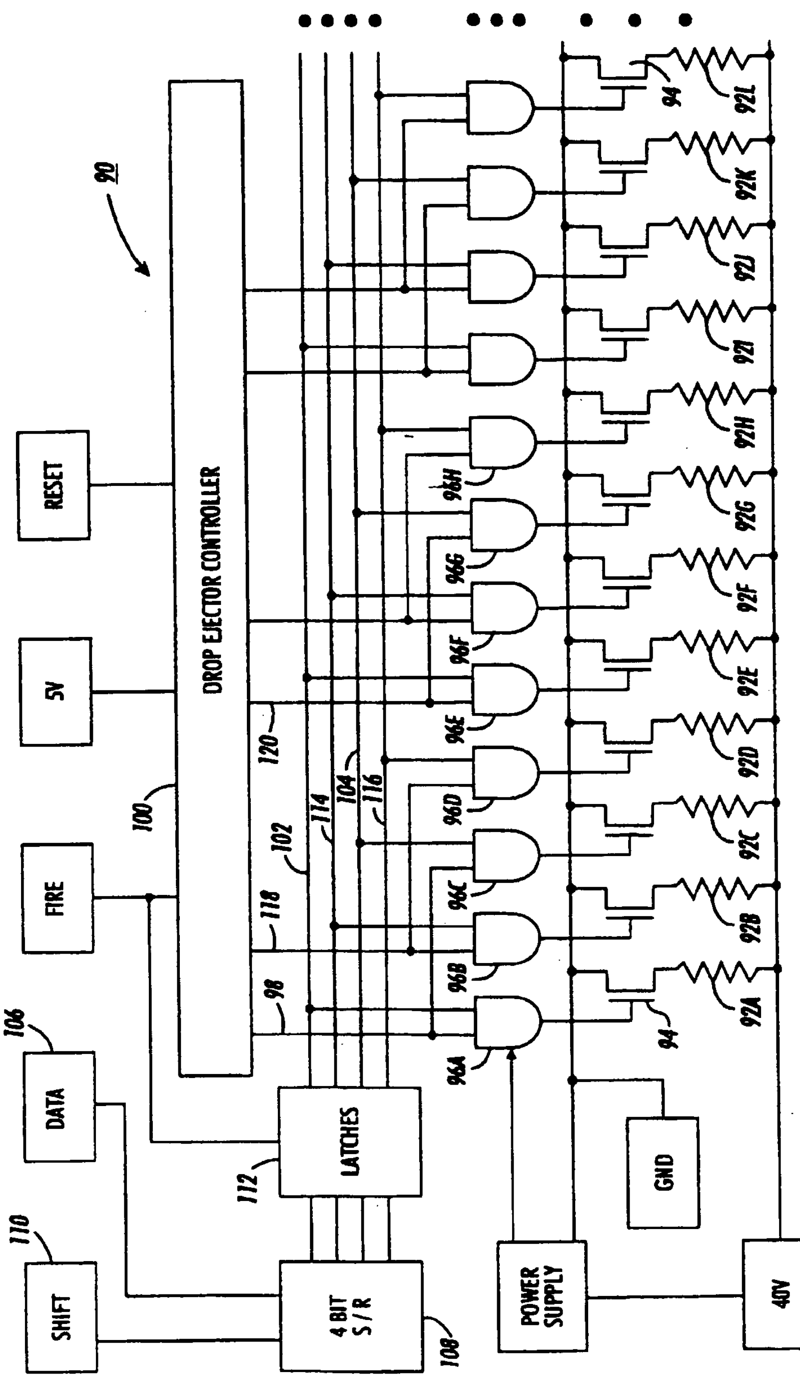

FIG. 4

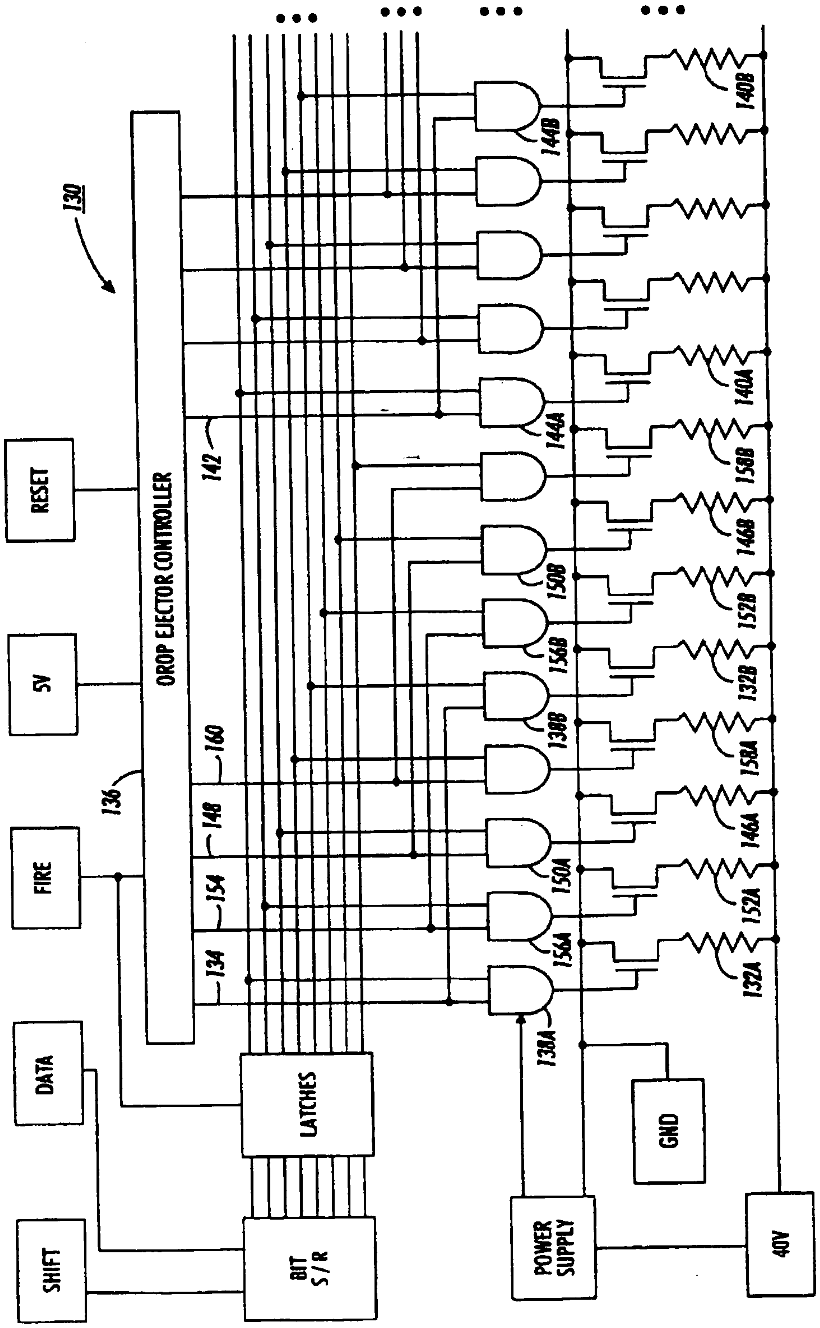
130
SHIFT
DATA
FIRE
5V
RESET
BIT S/R
LATCHES
DROP EJECTOR CONTROLLER
136
134
154
148
160
142
POWER SUPPLY
GND
40V
138A
156A
150A
138B
156B
150B
144A
144B
132A
152A
146A
158A
132B
152B
146B
158B
140A
140B

FIG. 5